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Possible Relationship between Extents of Divergence, Science Achievement and Attitudes towards Science

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Abstract

Every individual possesses a distinctive learning and thinking approach which is due to the unique cognitive learning style of the individual. Cognition elucidates an individual's customary and natural style of perceiving, thinking, and resolving the concerned problem. This study aimed to consider the convergent-divergent cognitive learning styles, in relation to attitudes and academic achievements of undergraduate science students. This descriptive study consists of a sample of 1222 randomly selected undergraduate science students. The data was collected through a standard test of divergent skills, an attitude questionnaire, and academic results of undergraduate science students. The results revealed that male students tend to be less divergent while being more divergent tends to associate with higher academic performance and more positive attitudes towards science. It was found that there is a tendency for those with less divergent skills to choose to study the sciences despite the fact that such skills are related to better performance. It is concluded that although it is not possible for teachers to respond to the wide range of variations in learning styles of their students. However, the way the curriculum in the sciences (and related areas) is devised needs re-thought and the way textbooks are developed may need radical overhaul. This pattern is interpreted and implications are discussed in this paper.

Keywords: Cognitive style, Convergent, Divergent, Attitude

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Introduction

Scientific advances, especially over the past 150 years, have changed human lifestyles in very dramatic ways. Thus, for example, the materials we can now employ and the communications and methods of travel that we use every day would be unrecognisable to someone living in the late 19th century. Education in the basic sciences started to make its way into schools during this period and the sciences are now seen as central elements in all school education. Young people today need to have some understanding of the contributions of the sciences in the way societies have developed worldwide (Pitafi & Farooq, 2012).

It has become fashionable to talk of scientific literacy although few have described this precisely. Scientific literacy can be seen under three broad headings:

Knowing what	Understanding some of the basic ideas that have developed through scientific enquiry
Knowing how	Understanding how the sciences have developed these insight in terms of the central role of experimentation
Knowing why	Appreciating the ways the findings of the sciences have changed individual lives and societies

Science has often been confused with technology and many have assumed wrongly that technological development arises neatly from scientific discoveries. The sciences seek to *understand* the world around while the technologies seek to *control* the world around. These are simply two different goals. Sometimes it is assumed that the outcomes are always beneficial (Köseoğlu, Atasoy, Kavak, Akkuş, Budak, Tümay, Kadayıfçı, & Taşdelen, 2003) that there is a neat relationship between scientific education and the solution of global issues (Van Eijck & Roth, 2007). The evidence does not support these assumptions. One major research development has shown that there are clear cognitive mechanisms that underpin all learning (Reif, 2008). While everyone learns in essentially the same way, in cognitive terms (Johnstone, 1997), there are important variations within this cognitive structure (Alamolhodaei, 2001; Ansburg, 2000; DeYoung, Flanders &Peterson, 2008; Mienaltowski, 2011, Hinda*et al.*, 2008, 2013).

Literature Review

One of the important variations relates to what is described as convergent and divergent thinking. Hudson (1966) pioneered the

research in this area but others have developed it further within education (Getzels & Jackson, 1962; Guilford, 1967). Insights have been hindered at times by unwarranted assumptions. For example, ignoring Hudson's original findings, most have assumed that convergent and divergent thought are opposites, implying that a person thinks (in varying degrees) one way or the other. The work of Hindal showed that Hudson was right (Hindan, 2007, 2014). Thus, Altun and Cakan (2006) built on this to think in terms of convergent or divergent personalities. The danger is that this ignores the possibility that a person might act in a divergent way in one context but be more convergent in another. Hudson saw them as two skills and that a person might possess either or both of the two skills in varying degrees. His test measured the extent of the skill of divergency. Overall, it is better to see divergence and convergency as two skills, not styles of learning.

Koballa's (1989) argued that teachers laid little emphasis on attitudinal objectives, despite being aware of the importance of student attitudes. These can influence the learner's choice of subjects, interests, involvement and, consequently, affect academic outcomes. However, this is inevitable, given over-crowded curricula and the emphasis on recall of information.

Numerous studies argued for the importance of attitudes related to the sciences (Aiken, Aiken, 1969; Koballa, 1988; Laforgia, 1988, Shah & Mahmood, 2011). Few studies considered the nature of attitudes, how they develop or how to measure them in rigorous ways. In one recent text (Khine & Saleh, 2011), the opening chapter does lay that foundation but, in studies throughout the world, the principles are frequently ignored.

Convergent and Divergent Thinking

The sciences develop their insights based on experimental observations, carefully gathered, often replicated and then interpreted. This process of science does require careful thinking and much has been analysed in relation to scientific thinking (Al-Ahmadi & Reid, 2011, 2012). It can be argued that such thinking involves convergent and divergent thought & Heywood (2005) proposed that "perhaps the best known cognitive styles are those that are described on the continuum of convergent-divergent thinking" (p. 228). Similarly, Zaman (2006) notes many studies in the area.

Convergent and divergent thinking have been analysed in some detail by Bahar (1999) and in detail by Hindal (2007, 2014). Convergent thinking can be thought of as the ability to draw together ideas to

generate some kind of conclusion. Clearly this skill has a place in the sciences. Divergent thinking can be thought of as the ability to generate many possibilities from some starting position. Hindal (2007, 2014) has summarised this:

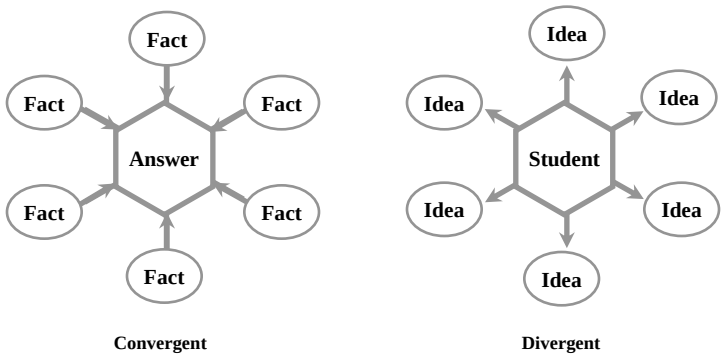

Figure 1: Convergent and Divergent Skills

Convergency and Divergency in relation to Science Education

Bhatti & Bart (2013) consider that many research studies show that learning styles are extremely effective and dominant as far as the academic performance of the student is concerned. However, this assumes cause-and-effect relationships. It may simply be association or a reflection of the way traditional assessment is undertaken.

Reynolds & Gerstein (1992) go further in arguing that, if the teachers and administration are well-aware of the students' learning and cognitive style, they can improve the quality of instruction. Clearly this is a logical nonsense for no teacher can respond to the multiplicity of learning styles present in any class. Numerous reviews have shown that many of the assumptions underpinning learning styles is simply not supported by the evidence (Coffield, Moseley, Hall, & Ecclestone, 2004; Kirschner&van Merrie¨nboer, 2013; Kirschner, 2017). While it is clear that convergent thinking and divergent thinking skills can be described and measured, evidence does not support the idea that students can *choose* which style to adopt or that teachers can respond the multiplicity of styles in any classroom.

Bhatti & Bart (2013) found that a convergent thinker tends to perform excellently in technical tasks but is less important in interpersonal relations. By contrast, a divergent thinker tends to perceive

concretely and thinks reflectively and imaginatively. They note that the fluency, creativity, flexibility, originality, and elaboration characteristic of divergent thinking tends to relate to the liberal arts, consistent with Hudson's (1966) original observations. When it comes to gender, Philbin, Meier, Huffman, & Boverie (1995) found that female students tend to be accommodators or divergent ones while male students were more assimilators or convergent in thinking.

Zhu (2013) found differences in the thinking styles of students and teachers and linked this to teacher–student interpersonal behaviors. Wu & Fazzarro (2013) cited Hudson's finding that the students of sciences mostly possess convergent style of thinking whereas the students of arts, humanities and languages mostly like a divergent style of thinking. Similarly, Negahi, Ghashghaeizadeh & Hoshmandja (2012) cited Homayuni et al. that the subjects like Mathematics and Empirical Science, which are studied with assimilated and convergent learning styles, are chosen by students more than the subjects which are studied under accommodated and divergent learning styles. While the students who possess accommodated and divergent learning styles generally select humanities, arts and languages more than the subjects which are studied under convergent thinking styles. However, all this may simply reflect the way the sciences are presented and assessed.

Clark (2012) quoted Evans, Forney, Guido, Patton, & Renn (2010) that, "convergent, divergent, assimilation, and accommodative are the basic four categories of learning styles. Convergent learners like to go with the abstract conceptualization and active experimentation and are liable to be good problem solvers and decision makers" (p. 40). However, divergent learners are social-oriented and depend on concrete experience and reflective observation for providing solutions to problems by employing diverse viewpoints. When a learner begins to integrate additional learning dimensions into his/her preferred learning style, his/her creative and cognitive capabilities start mounting and enhancing which is a sign cognitive development. However, all kinds of assumptions underpin this analysis and recent work certainly questions this (Kirschner&van Merrie¨nboer, 2013; Kirschner, 2017).

Kolb (2007) developed a learning style inventory by investigating the styles of higher grade achievers in computer programming (cited in Yeboah & Sarpong, 2012). Kolb's study (2007) exposed that as far as the grade achievement of the learners is concerned, few learning styles seemed better than the other ones. A significant and indicative difference was revealed between student's learning styles and their academic achievement. In terms of grade achievement, the research showed that

divergent learners were far better than the convergent ones. This is consistent with numerous others studies (Danili & Reid, 2004). However, the Kolb study relies on self-report with all its known weaknesses.

Methodology

The aim of the study was to relate measured extent of divergency with academic performance in science and attitudes to science. A large sample (N = 1222) of undergraduate science students of basic sciences, computer sciences, and engineering sciences disciplines was selected, this being typical of the university population undertaking science-related studies.

A modified version of the original Hudson test was employed to measure extent of divergency while a structured questionnaire was developed for obtaining responses from student regarding their attitude towards science. Academic achievement records of undergraduate science students were obtained from their respective universities/ degree awarding institutions.

Bahar, Johnstone & Hansell (1999) developed the extent of divergency test. Originally, it was considered that a low score on this test indicated convergent until the concept of convergency was shown to be a separate variable (Hindal, 2007, 2014). This test has been used widely and its validity and reliability are well-established (Bahar, Johnstone & Hansell, 1999; Bhatti, 2013; Hindal, 2007, 2014; Hindal, Reid & Whitehead, 2008; Danili & Reid, 2004). The best involves six sub-tests and the established prescribed scoring criteria were used. In this, every valid response is given one point and there is, therefore no maximum score: the more ideas generated then higher the score.

When used with the sample of 1222, the following data were obtained (table 1):

Table 1:
DescriptiveStatistics for Convergent-Divergent Learning Style Test

N	Maximum score	Mean	St Dev
1222	101	47	18.1

The range of scores generated a close to normal distribution (figure 1).

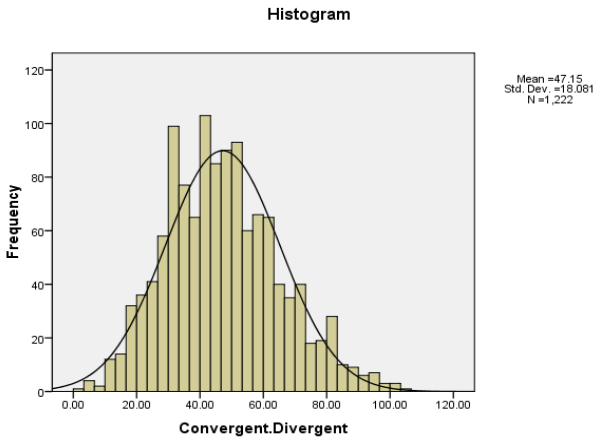

Figure 2: Distribution Graph of Convergent-Divergent learners

Following the approach developed by Bahar *et al.* (1999), the range of scores was divided into three groups:

Low score	mean – 1(S.D)	Weak in divergent thinking skills
Average score	mean ± 1(S.D)	Moderate in divergent thinking skills
High score	mean + 1(S.D)	Strong in divergent thinking skills

With the data obtained, scores ≤ 29 were classified as weak in divergent thinking skills, scores ≥ 65 were classified as strong in divergent thinking skills, leaving scores between 29 and 65 as moderate.

Attitude Questionnaire

An attitude towards science questionnaire, consisted of forty items, was developed for this study. This scale was used to identify the trend of attitude (positive or negative) and strength (strongly agree or strongly disagree) towards science. In doing this, ordinal numbers have been added and the 'scores' obtained, therefore' must be treated as merely indicative.

Reliability and Validity of Research Tools

The extent of divergency test is known to be valid and reliable and a test-retest reliability check here gave a correlation of 0.94. The validity of questionnaire items is difficult to establish and the finding there must

be treated with some caution. However, other studies (Reid, 2003) have shown that reliability is rarely an issue.

Results

Table 2:
Scores on divergency test

Learning Style	**Test Score**	**Gender**				**Total**	
		Male	*%*	*Female*	*%*		*%*
Low score	0-29	153	23.1	47	8.4	200	16.4
Average score	29-65	451	68.0	380	68.0	831	68.0
High score	65-130	59	8.9	132	23.6	191	15.6
Total		**663**	**100**	**559**	**100**	**1222**	**100**

The work of Hindal has shown that convergency is not the opposite of divergency (Hindal et al, 2009, 2013 and 2014), confirming the original insights of Hudson (1966) although older studies have considered them as opposites (Klausmeier &Wiersma, 1964; Dudek, Strobel & Runco, 1993). Gender differences were considered (table 2).

Table 3:
Extent of divergency and gender

N = 1222	Sample	Low Score	Moderate Score	High Score	χ^2	*df*	*p*
Male	663	153	451	59	81.9	2.0	< 0.001
Female	559	47	380	132			

This shows that the females performed better in the test of divergency and can be regarded as more divergent. This finding is consistent with that of Hindal *et al* (2013) which was set in a Middle Eastern country.

Any potential relationship between attitudes towards science and extent of divergence are considered in table 4.

Table 4*:*
Extent of divergency and attitude

	N	Mean	SD	t	*p*
Attitude of those with low extent of divergency	200	3.5	0.47	- 6.5	< 0.001
Attitude of those with high extent of divergency	191	3.8	0.49		

The attitude scale was scored on 5 point Likert scale. The calculations were made using mean on 5 point Likert scale. The means and standard deviations are computed from data that are ordinal in nature and must be treated with caution. However, it does appear that those with higher levels of divergency hold more positive attitudes.

Table 6 summarises any possible relationship between extent of divergence and academic achievement.

Table 6:
Academic achievement of convergent and divergent students

Variable	N	Mean	SD	t	*p*
Performance of those with low extent of divergency	200	2.5	0.75	-8.0	< 0.001
Performance of those with high extent of divergency	191	3.1	0.65		

Table 6 shows that that those who perform(CGPAs) better are those who tend to be more divergent.

Discussion

The results revealed that male science students tend to be less divergent than female science students in their thinking. Being more divergent tends to associate with higher academic performance and more positive attitudes.

There is the strange paradox that, while being more divergent associates with higher performance in the sciences and related subjects,

those who choose to pursue scientific studies tend to be those who are LESS divergent. Overall, this must reflect deficiencies in the way the sciences are presented (textbooks and assessments may be important here). Thus, Roue (2014) argues for the value of divergent thought (creativity) in science and engineering.

The gender pattern confirms what has been found in many studies (Çakıroğlum 2014). There is no evidence that gender gives any overall bias towards convergency or divergence in the wider population (Roue, 2014). It seems that the males who choose to study in the sciences tend to be less divergent and this must reflect the way they have been taught and/assessed at school stages. However, the females have undergone similar educational experiences. Thus, the way the males are viewing their educational experience must be different in some way.

However, there is no consistency in the gender findings across many studies but this may reflect faulty measurement (mainly the use of self-report which is known to be inappropriate) or differences across cultures. Thus, several studies found females more divergent (Klausmeier &Wiersma, 1964; Dudek, Strobel & Runco, 1993; Klausmeier &Wiersma, 1964; Bhatti, 2001; DudekStrobel, & Runco1993; Artola, 2013). Chen & Macredie (2002) found males more divergent while Reese *et al.* (2001) found no differences. Thomas & Berk (1981) noted gender differences with very young children while Kuhn &Holling (2009) found that extent of divergency grew with age. Linn &Hyde (1989), as well as Yim (2009), argued that gender differences are not general but reflect specific cultural and situational frameworks.

The test originally developed by Hudson is known to valid and reliable. Many *assumed* that a low score indicated convergent thinking but this has been shown not to be true. Convergent thinking and divergent thinking are just two different aspects of thinking and cannot be seen as *'opposites*'. This was demonstrated very clearly by Hindal (2007, 2014) when she developed a test for extent of convergent thinking and found that the outcomes of this test correlated highly with the outcomes of the established test of divergent thinking, an outcome confirmed later by Hindal*et al.* (2009).

There is a difficulty in that most studies *assumed* that low scores indicated convergency. Almost all studies show that being divergent (high scores) is an advantage in all academic assessment (for example Peker, 2009 found it true for mathematics while Hindal, 2007, 2014 found it true in all subject areas). However, when scores in the test for convergency were related to academic performance, consistently it was found that being strongly convergent was also an advantage (Hindal,

2007, 2014). Hindal tried to relate this finding to the way assessment is typically set as well as the way information is processed in the brain. While it can be argued that being able to generate ideas and possibilities is an advantage when trying to answer examination questions, being able to develop a clear '*right*' answer is also an important skill. Overall, both convergent and divergent cognitive learning skills are important for the better performance of students (Danili & Reid, 2004).

Positive attitudes are always found to relate to better academic performance. Neither causes the other - they are simply associated. In one study (Jung &Reid, 2009); the reasons behind this were explored. It was found that those with higher working memory capacity were capable of understanding science better (thus performing better) and developed more positive attitudes. Those with lower working memory capacity faced understanding difficulties and tended to rely more on memorisation. Given that the natural way for all human learning is seeking to understand, this made the entire learning process less attractive and attitudes towards science deteriorated. This provides the key to the attitude area. In simple terms, if we arrange the leaning in line with the initiations imposed by working memory capacity, then the attitudes will take care of themselves, a point ignored in most studies that have looked at attitudes to science.

Conclusions

The study confirms that there is a tendency for those with LESS divergent skills to choose to study the sciences despite the fact that such skills are related to better performance. The trend is more marked with the men. In some way, the way the sciences are presented at younger ages (compared to the other subjects of the curriculum) is attracting in those who are less divergent. This suggests that the way the curriculum and assessment are constructed give inadequate opportunities for learners to have the freedom to generate ideas, to be creative and remain open-minded.

It is not possible for teachers to respond to the wide range of variations in learning styles of their students. However, the way the curriculum in the sciences (and related areas) is devised needs re-thought and the way textbooks are developed may need radical overhaul. Science education needs to learn from other curricular areas and offer much more scope for divergent thinking skills, for critical and creative thought, perhaps being less tied down to teaching learners to think only in terms of fixed right answers

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